Paul He

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Education

University of Toronto, BSc in Computer Science (Honours)　　　　　　　　　　Sep 2021 – May 2025
- Graduating with High Distinction

ETH Zürich, Exchange Year in Computer Science　　　　　　　　　　　　　　Sep 2023 – Aug 2024
- Completed graduate-level coursework in NLP and Machine Learning

Research Experience

Sensitive Functions and the Limits of Self-Attention in NLP　　　　　　　Jan 2025 – Present
Supervisor: Prof. Gerald Penn　　　　　　　　　　　　　　　　　　　　University of Toronto
- Studying the presence and impact of sensitive Boolean functions (e.g., parity) in natural language understanding tasks.
- Analyzing whether models like BERT can represent such functions or fail due to attention limitations.

Causal Reasoning Evaluation for Language Models　　　　　　　　　　　Jan 2025 – Present
Supervisor: Prof. Zhijing Jin (Jinesis AI Lab)　　　　　　　　　　　　　　　Vector Institute
- Developing a tool to parse and evaluate causal expressions generated by LLMs, using BFS to match equivalent causal formulas and identify reasoning errors.
- Aiming to use this as a proxy to improve QA tasks involving causal understanding.
- Planning to submit this work to EMNLP 2025.

Polynomial-Time CCG Parsing: An Empirical Evaluation of the Kuhlmann–Satta Algorithm　　Sep 2025 - Dec 2025
Supervisor: Prof. Dr. Gerald Penn　　　　　　　　　　　　　　　　　　University of Toronto
- Designed and implemented a polynomial-time parser for Combinatory Categorial Grammar (CCG).
- Conducted large-scale multilingual experiments to analyze when symbolic parsers outperform naive baselines, identifying empirical complexity thresholds.
- First-author paper under review at the 18th International Conference on Parsing Technologies (IWPT 2025).

Unsupervised Prompt Optimization for RAG using PMI　　　　　　　　　Jun 2024 – Sep 2024
Supervisors: Tianyu Liu, Prof. Ryan Cotterell (Rycolab)　　　　　　　　　　　ETH Zürich
- Investigated attribution methods such as change in Jensen-Shannon divergence for Fisher information to approximate attention weights in LLMs.
- Developed and implemented an unsupervised method to reorder retrieved documents using PMI, improving QA accuracy by up to 4% on NQ-Open and ELI5.
- Presented the work at NAACL 2025 poster session, attracting sustained interest from researchers across academia and industry.

Publications

Pointwise Mutual Information as a Performance Gauge for Retrieval-Augmented Generation　　2025
Tianyu Liu, Jirui Qi, *Paul He*, Arianna Bisazza, Mrinmaya Sachan, Ryan Cotterell
NAACL 2025 (Main), https://aclanthology.org/2025.naacl-long.78/

Projects

Speeding up Earley's Algorithm　　　　　　　　　　　　　　　　　　Mar 2024 - Aug 2024
- Proposed and implemented a grid search approach, which resulted in an algorithm $\times 5$ faster than the naive algorithm.
- Tested and experimented with the proposed algorithms on Treebank datasets to validate theoretical findings.

Word Segmentation and Part-of-Speech Tagging with Transformer　　　　Oct 2023 - Jan 2024
- Designed a new decoder embedding mechanism to better capture subtle linguistic nuances and dependencies.
- Implemented the mechanism and achieved state-of-the-art results with a validation accuracy of 96.29%.

Skills

Programming Languages: Python, C, Java, SQL

Spoken Languages: English (Fluent), Mandarin (Proficient), German (Proficient)